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Abundance and Run Timing of Adult Salmon in the Kwethluk River, Yukon Delta National Wildlife Refuge, Alaska, 2001

Timothy G. Roettiger
Ken C. Harper
Andy Chikowski
U.S. Fish and Wildlife Service
Kenai Fish and Wildlife Field Office
P.O. Box 1670
Kenai, Alaska 99611
(907) 262–9863

This project (FIS 00-019) was conducted in cooperation with the Organized Village of Kwethluk. Funding was made available under Cooperative Agreement 70181J258 between the U.S. Fish and Wildlife Service and the Organized Village of Kwethluk.

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This project (FIS 00-019) was funded under Cooperative Agreement 70181J258 between the U.S. Fish and Wildlife Service and the Organized Village of Kwethluk. The Cooperative Agreement provided funding to the village, to help with their capacity in becoming active partners in monitoring important Yukon Delta National Wildlife fisheries resources that are used for subsistence by the people of Kwethluk and other Kuskokwim River Villages. As a partner Kwethluk hired personnel locally and purchased operational supplies and equipment. The Organized Village of Kwethluk provided the administrative support and direction to their employees and promoted project understanding to the people they represent in the village. There were many from Kwethluk that contributed to the success of the Kwethluk River weir. Abraham Alexi Jr., Oscar Larson, and Robert Michael were instrumental with fish counts, staging, and resupply at the weir. John Owens, Chariton Epchook and Boris Epchook, helped with administration and other support functions. Oscar Larson also provided direct project support, administration of village reports, and inventory controls.

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Tim Roettiger, Ken Harper, and Andy Chikowski
U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office
PO Box 1670, Kenai, Alaska 99611, (907) 262-9863

Abstract. - From August 12 to September 13, 2001 a resistance board weir was used to collect abundance, run timing, and biological data from the salmon returning to the Kwethluk River, a tributary of the lower Kuskokwim River. This was the second year of a cooperative project with the Organized Village of Kwethluk, initiated under the Federal Subsistence fishery management program to provide reliable data necessary for managing the Yukon Delta National Wildlife Refuge fishery resources that contribute to major subsistence and commercial fisheries.

A total of 353 chum *Onchorhyncus keta,* 129 chinook *O. tshawytscha,* 67 sockeye *O. nerka,* 102 pink *O. gorbuscha*, and 19,196 coho *O. kisutch* salmon were counted through the weir. Due to high water, weir installation and operations were delayed. All species, with the exception of coho, were past the peak of their spawning migration when counts started. Peak weekly passage for coho occurred during the week of August 26 to September 1. Additionally, from August 21-22 and September 7-8, only partial counts were obtained due to high water conditions. Cumulative escapement records from previous weir operations indicate that a large proportion of all other species migrations were missed prior to weir installation.

Only coho salmon had sufficient samples collected for sex and age composition estimates. Females made up the majority at 51.4%. Age groups were partitioned: 1.1 12.4%, 2.1 85.6% and 3.1 2.0%.

In addition to the salmon, 3 Dolly Varden *Salvelinus malma*, 5 Arctic grayling *Thymallus arcticus,* and 463 whitefish (*Coregonus* spp.) were counted.

Introduction

The Kwethluk River, a lower Kuskokwim River tributary located on the Yukon Delta National Wildlife Refuge (Refuge), provides important spawning and rearing habitat for chum *Onchorhyncus keta,* chinook *O. tshawytscha,* sockeye *O. nerka,* pink *O. gorbuscha*, and coho *O. kisutch* salmon (Figure 1) (Alt 1977; U.S. Fish and Wildlife Service 1992). Adult salmon returning to the Kwethluk River migrate 159 river kilometers (rkms) through the lower Kuskokwim River before reaching the Kwethluk River, and then migrate upstream as many as 160 rkms to reach spawning grounds. In the lower Kuskokwim River, salmon pass through one of Alaska's most intensive subsistence fisheries (Burkey et al. 2001; U.S. Fish and Wildlife Service 1988).

The Alaska National Interest Lands Conservation Act (ANILCA) mandates that salmon populations and their habitats be conserved in their natural diversity within the Refuge; that international treaty obligations be fulfilled; and that subsistence opportunities for local residents be maintained. Salmon escapement studies for the lower Kuskokwim River tributaries on the Refuge are ranked as priorities in the Refuge Fishery Management Plan (U.S. Fish and Wildlife Service 1992). Compliance with ANILCA mandates, however, are not ensured when reliable data regarding fish stocks originating within the Refuge are not available.

Adequate escapements to individual tributaries and main stem spawning areas are required to maintain genetic diversity and sustainable harvests, but management is complicated by the mixed stock nature of the Kuskokwim River fishery. Managers attempt to distribute the catch over time to avoid overharvesting individual stocks, since each may have a distinct migratory timing (Mundy 1982). Stocks or species returning in low numbers or early and late portions of the runs may be overharvested incidentally during the intensive harvesting of abundant stocks. Escapement data are lacking on many of these individual stocks in the Kuskokwim River drainage and are needed for more precise management.

In accordance with ANILCA mandates, the U.S. Fish and Wildlife Service (Service) initiated a three-year study of the Kwethluk River in 1992 to : (1) enumerate adult salmon; (2) describe the run timing of chum, chinook, sockeye, pink, and coho salmon returns; (3) estimate the age, sex, and length composition of adult chum, chinook, sockeye, and coho salmon populations; and (4) identify and count other fish species passing through the weir. High water precluded the installation and operation of the weir in 1991, and the weir was operated only in 1992.

Resolutions opposing the weir were passed by village leaders in September 1992 and consequently weir operations were discontinued. In 1996, the Association of Village Council Presidents (AVCP) initiated a counting tower project which operated through 1999. Complete counts for chum, chinook, and sockeye salmon were obtained only in 1996 and 1997 because high water delayed operations until late July in 1998 and 1999. In all years of the tower project, high water prevented operations beyond mid-August; therefore, few data exist regarding the abundance and run timing of coho and pink salmon for those years. Additionally, sampling for age, sex and length information was unsuccessful in 1996 and 1997, and sampling was discontinued in successive years (Cappiello and Sundown 1998; Cappiello and Chris 1999). No comprehensive sampling data exist for the years of tower operation.

Study Area

The Kwethluk River is in the lower Kuskokwim River drainage (Figure 1). The region has a subarctic climate characterized by extremes in temperature. Temperatures range from summer highs near 15°C to average winter lows near -12°C (Alt 1977). Average yearly precipitation is approximately 50cm with the majority falling between June and October. The rivers generally become ice free in the slow-moving sections by early May and freeze-up occurs in late November. The Kwethluk River originates in the Eek and Crooked Mountains, flows northwest approximately 222 km, and drains an area of about 3,367 km². Braiding and gravel substrates are found in the middle section of the river where the weir was placed. Below the middle section, the lower 47 km consists of a deeper, muddy-bottomed channel averaging 53 m in width (Alt 1977). Turbid water conditions that also are characteristic of this lower section are the result of active stream cutting on tundra banks.

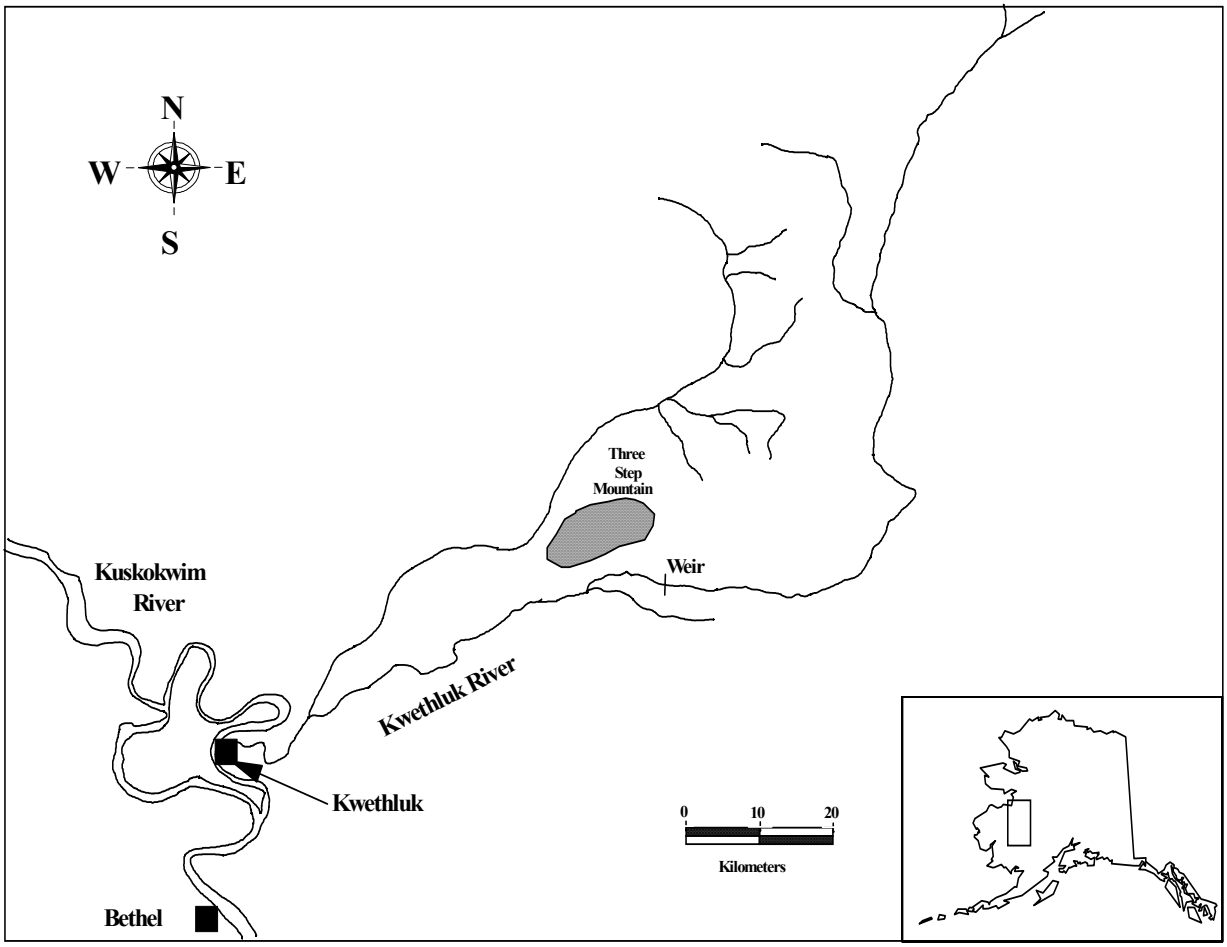

Figure 1. - Location of Kwethluk River Weir

Methods

Weir Operation

A resistance board weir (Tobin 1994) spanning 56 m was installed in the Kwethluk River (62°07'N, 162°48'W) approximately 88 rkm upstream from the Kuskokwim River and 43 air-km east of Kwethluk, Alaska (Figure 1). This location is approximately 2.4 rkm downstream from the 1992 weir site described by Harper (1998). The weir was moved downstream to this section of river in 2000 due to a change in channel morphology at the old location. A staff gauge was installed upstream of the weir to measure daily water levels. Staff gauge measurements were correlated to correspond with the average water depth across the river channel at the upstream edge of the weir. Water temperatures were collected at the site, August 12 through September 15, daily, generally between 0800 and 1200 hours.

One live trap and one count passage area were installed to facilitate sampling and efficient fish passage during various river stage heights. All fish were enumerated to species as they passed through the live trap or counting passage (Harper 1998). Salmon and resident species that did not pass through these areas, but escaped upstream through the gaps between pickets were not counted. Picket spacing of 4.8 cm, is wider than the 3.5 cm spacing used in 1992. Panels with wider picket spacing were designed to remain functional during greater water flow and allow passage of smaller pink salmon between pickets. Fish were passed and counted intermittently between 0001 hours and midnight each day. The duration of counting sessions varied depending on the intensity of fish passage through the weir and was recorded to the nearest 0.25 hour at each counting station.

The weir was inspected for holes and cleaned daily. An observer outfitted with snorkeling gear checked weir integrity and substrate conditions. Cleaning consisted of raking debris from the upstream surface of the weir or walking across each panel until it was partially submerged, allowing the current to wash accumulated detritus downstream.

Estimates of missed salmon passage

For days when high water or a late start prevented counts, estimates were made using historical percent passage data from previous years with complete data. The passage for the jth day with missing data was estimated as

$$\hat{n}_j = \left[\frac{\sum_{i=1}^{D} \theta_i n_i}{1 - \sum_{i=1}^{D} \theta_i p_i} \right] p_j, \qquad (1)$$

where:

$\mathbf{n_i}$ = weir passage on day i,

$\mathbf{p_i}$ = proportional passage on day i based on historical data,

$\mathbf{2_i}$ = an indicator variable defined as 1 if passage was observed on day i, 0 otherwise, and

D = number of days in the season.

Biological Data

Sample weeks, or strata, began on Sunday and ended the following Saturday. However, partial weeks of weir operation shortened the length of the last strata. Sampling generally commenced

near the beginning of the week, and an effort was made to obtain a weekly quota of 210 chum, 210 chinook, 210 sockeye, and 170 coho salmon in as short a period (1-3 days) as possible, to approximate a pulse or snapshot sample (Geiger et al. 1990). All target species within the trap were sampled to prevent bias.

Fish sampling consisted of measuring length, determining sex, collecting scales, and then releasing the fish upstream of the weir. Length was measured from mid-eye to the fork of the caudal fin and rounded to the nearest 5mm. Sex was determined by observing external characteristics, including verifying reproductive organs. Scales were removed from the preferred area for age determination (Koo 1962, Mosher 1968). Three scales were collected from each chum salmon, one from each sockeye salmon, and four scales from each chinook and coho salmon. Scale impressions were made on cellulose acetate cards using a heated scale press and examined with a microfiche reader. An Alaska Department of Fish and Game (Department) biologist determined age and reported results according to the European Method (Koo 1962).

Mean lengths of males and females by age were compared using a two-tailed *t* test at α=0.05 (Zar 1984). Age and sex composition were estimated using a stratified sampling design (Cochran 1977). Chi-square contingency table analysis was used to test for differences in age composition between the sexes. Because the standard test only applies to data collected under simple random sampling, adjustments were made to the test statistic, following Rao and Thomas (1989), to account for the impact of our stratified sampling design on the results. The χ^2 statistic, hereafter referred to as $\chi^2(\delta)$, was divided by the mean generalized design effect, δ, as a first-order correction to the standard test (Rao and Thomas 1989). Estimated design effects for the cells and marginals are presented in the results. Age and sex specific escapements in a stratum, $\hat{A}_{hij}$, and their variances, $V[\hat{A}_{hij}]$, were estimated as:

$$\hat{A}_{hij} = N_h \hat{p}_{hij} ; \qquad (2)$$

and

$$\hat{V}[\hat{A}_{hij}] = N_h^2 \left(1 - \frac{n_h}{N_h}\right)\left(\frac{\hat{p}_{hij}(1-\hat{p}_{hij})}{n_h - 1}\right) \qquad (3)$$

where

N_h = total escapement of a given species during stratum *h*;

$\hat{p}_{hij}$ = estimated proportion of age *i* and sex *j* fish, of a given species, in the sample in stratum *h*; and

n_h = total number of fish, of a given species, in the sample for stratum *h*.

Abundance estimates and their variances for each stratum were summed to obtain age- and sex- specific escapements for the season as follows:

$$\hat{A}_{ij} = \sum \hat{A}_{hij} ; \qquad (4)$$

and

$$\hat{V}[\hat{A}_{ij}] = \sum \hat{V}(\hat{A}_{hij}) ; \qquad (5)$$

where

$\hat{A}_{ij}$ = estimated total escapement for age *i* and sex *j* fish of a given species.

Results

Weir Operation

Due to high water, weir installation and operations were delayed until August 12. All salmon species, with the exception of coho, were past the peak of their spawning migration when enumeration started. Additionally, on August 21-22 and September 7-8, only partial counts were obtained due to high water conditions. Escapement counts from previous years' operations indicate that significant proportions of all migrations were missed.

The weir was operational starting at 2030 hours on August 12, 2001. Prior to this fish could pass the trap and were not enumerated. The weir was functional throughout most of the operational period (August 12 to September 13). Stage heights averaged 50.0cm with a high of 74.4 and a low of 22.0 (Appendix 1). Water temperatures averaged 10.5°C with a minimum of 8.0 and a maximum of 14.0 (Appendix 1).

An exposed bank approximately 100m above the weir adversely affected water turbidity. This bank was susceptible to continuous erosion due to high water from seasonal freshets. Pieces of tundra sod frequently washed onto the weir and into the counting chute during periods of rising water levels. The highest water levels coincided with the greatest debris accumulation.

Biological Data

A total of 353 chum, 129 chinook, 67 sockeye, and 102 pink, and 19,196 coho salmon were counted upstream through the weir (Figure 2, Appendix 2). Other species counted through the weir included: three Dolly Varden *Salvelinus malma,* 463 whitefish, *Coregonus* spp., and five Arctic grayling *Thymallus arcticus* (Appendix 2).

Chum Salmon - Chum salmon (N=353) passed through the weir from August 12 to September 13. The majority (85%) passed through the weir the week of August 12 to August 18. Small numbers of stragglers (<10/day) continued to pass through the weir until its removal. Only one chum was observed with gill net marks. Age and sex data were collected from only five fish, so no meaningful results could be obtained.

Chinook Salmon - Chinook salmon (N=129) passed through the weir from August 12 to September 13. The majority (94%) passed through the weir during the week of August 12 to August 18. No more that 4 fish were seen on any one given day after August 18. Two chinook were observed with gill net marks. Age and sex data were collected from only 2 fish at the weir so no meaningful results could be obtained on sex ratios or ages. In addition one hundred chinook salmon were captured using 11.4 cm. (bar measure) gill nets for genetic samples. Scale samples were collected and the fish released (Appendix 3).

Sockeye Salmon - Sockeye salmon (N=67) passed through the weir for the duration of the operational period (August 12 to September 13). The majority (97%) passed through the weir the week of August 12 to August 18. Only two fish passed after this date. No fish were observed with gill net marks, and no age or sex data were collected.

Pink Salmon - Although weir picket spacing allows some pink salmon to pass upstream uncounted, 101 were counted from August 12 to September 13. This was an off year and pink salmon numbers would be expected to be low. The majority (60%) of pink salmon passed through the weir during the week of August 12 to August 18. Small numbers (<10/day) continued to pass until the weir was removed.

Coho Salmon - Coho salmon (N=19,196) passed through the weir for the duration of its operational period (August 12 to September 13). Median passage occurred on August 25. Gill net marks were observed throughout the season on approximately 2% (N=320) of the escapement. Due to high water at the start of operations and again for two days each in both August and September, a substantial portion of the run was missed. A reconstruction of the complete run was created using previously collected data. This produced an estimated run of 21,595 fish and indicates that approximately 9% of the run was missed.

Three age groups were identified from the 181 coho salmon sampled from the weir escapement between August 15 and August 29 (Appendix 6). Females comprised an estimated 51% of this escapement. Age 2.1 fish were the most abundant at an estimated 86% of the run.

Due to small sample size, chi-square tests for differing age composition between sexes were not valid. Among sampled fish the mean length at age for age 1.1 males (595 mm) was significantly larger than for females (573 mm) (two-tailed t-test, $t=4.25$, $df=20$, $p<0.05$). Mean length at age for age 2.1 males (606 mm) did not differ significantly from females of the same age (592mm) (two-tailed t-test, $t=1.98$, $df= 153$, $p > 0.05$).

Discussion

Weir Operation

Picket spacing allowed pink salmon and smaller resident fish to pass upstream without being counted, yet was effective for the enumeration of other salmon species. Consequently, pink salmon, Dolly Varden, whitefish, and northern pike counts are below actual passage.

High water resulted in incomplete counts on two occasions: August 21-22 and September 7-8. Data collected on coho salmon indicated that nearly all the run was counted, so an estimate was generated. (Appendix 4). Only limited data for chum, chinook sockeye, and pink salmon were collected, so no attempt was made to estimate run sizes.

Biological Data

Due to low numbers of returning chinook and chum salmon, commercial fishing was closed on the Kuskokwim River in June and July. District W-1 had ten commercial fishing periods during the coho salmon season. District W-2 had none. Based on data from the Bethel test fishery and seven cooperatively operated escapement projects within the Kuskokwim drainage, it appeared that chinook and chum salmon runs were below average but larger than in 2000. Due to the continuing low returns of chinook and chum salmon, the Alaska Board of Fisheries and the U.S. Fish and Wildlife Service adopted a schedule of four consecutive days of subsistence fishing followed by three days of closure, during June and July (Alaska Department of Fish and Game, 2001).

Kruse (1998) suggests that anomalous conditions that existed in the marine ecosystem during 1997 and 1998 may have adversely affected the growth and survival of salmon in the ocean. These unfavorable conditions would have negatively impacted the older age classes that returned in 2001.

Because such a large proportion of the runs of chinook, chum, pink, and sockeye salmon were missed, no valid conclusions can be drawn from data collected regarding these species.

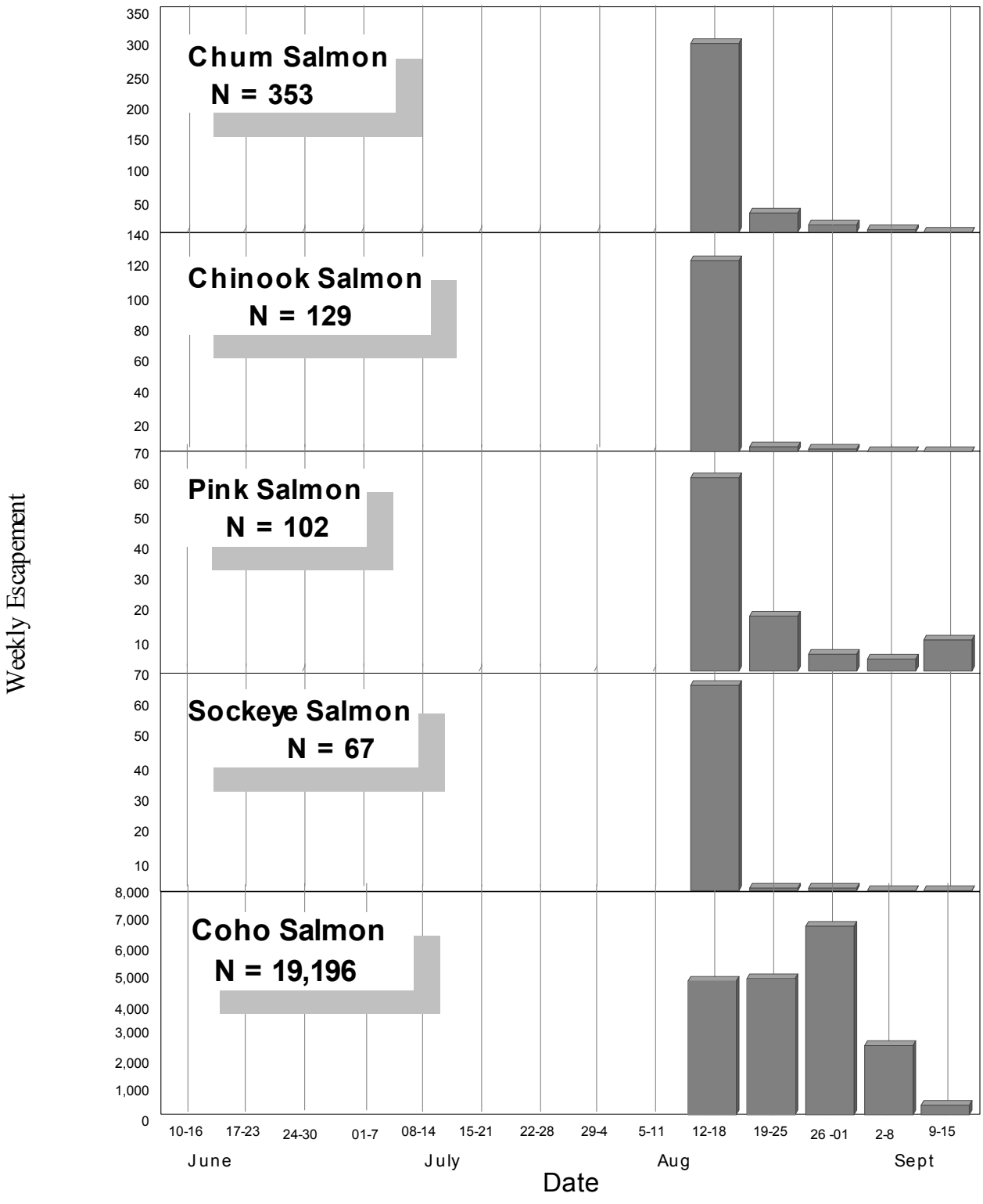

Figure 2.- Chum, chinook, sockeye, pink, and coho salmon weekly escapement through the Kwethluk River weir, Alaska, 2001.

Coho Salmon - The coho salmon return to the Kwethluk River was the most fully enumerated, (N=19,196). However, it was apparent that at least a small portion of the run was missed. Using previous data from the Kwethluk River, an estimate of the total run was generated. The estimated value (N=21,595) indicated that about 9 % of the run was missed. Past experience indicates this would be a reasonable conclusion. Using the estimated value, the 2001 coho run was approximately 84.3% of the 2000 run and 47% of the 1992 run (Figure3). According to state sources, drainage-wide the coho salmon run was about average in magnitude (Alaska Department of Fish and Game 2001). The observed median passage date of August 26 was the same as the 1992 and only five days later than in 2000 (Harper and Watry 2000).
The proportion of gill net-marked fish observed, 2%, was lower than in 1992 and 2000, 3% and 2% respectively.

Overall, females constituted 51% of the coho salmon run. This figure may be skewed because data were collected in only two strata. This is higher than in 1992 and 2000, 45% and 43% respectively (Harper and Watry 2000). This is also higher than the average proportion of females (46%) in the commercial catch from 1984-1998 (Molyneaux and DuBois 1999).

The Alaska Department of Fish and Game in cooperation with the Kuskokwim Native Association operated fish wheels at Kalskag and Birch Tree Crossing for the purposes of tagging coho salmon. Six tagged coho salmon, four from Kalskag, two from Birch Tree Crossing, passed through the weir. The fish from Kalskag would have had to travel approximately 150 rkm downstream to reach the mouth of the Kwethluk River. Fish from Birch Tree Crossing would have had to travel 114 rkm downstream.

Recommendations

The Kwethluk River weir continues to be an important tool for monitoring salmon stocks originating within the Yukon Delta National Wildlife Refuge. It also continues to provide important information used by the Alaska Department of Fish and Game in the management of the Lower Kuskokwim River Fisheries.

Based on this year's experience with high water, it is recommended that the weir be installed earlier, before the peak spring runoff. Once installed, operations should continue until the middle of September to ensure a complete count of returning coho.

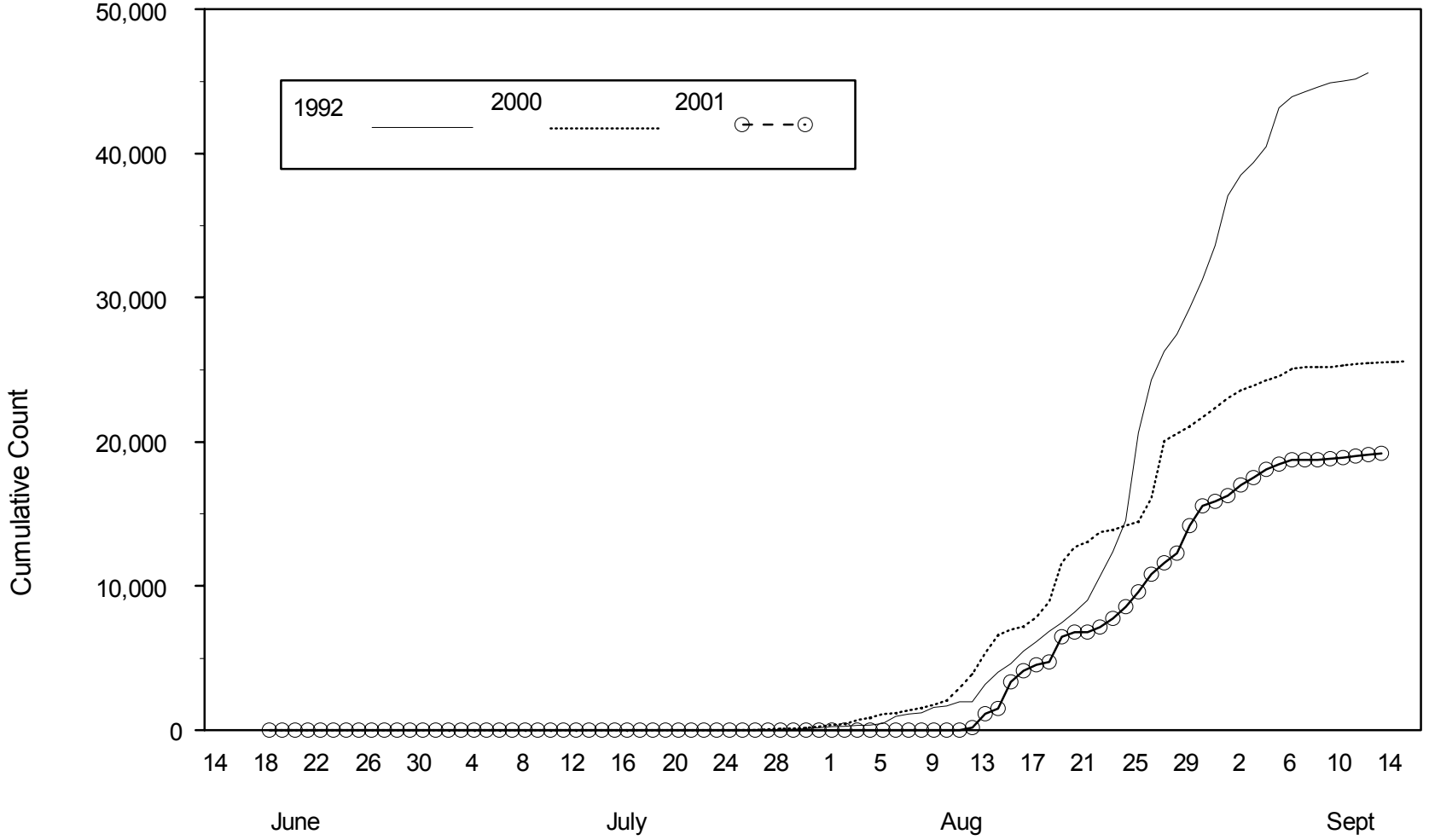

Figure 3.-Cumulative proportion of coho salmon escapement in 1992, 2000, and 2001 through the Kwethluk River weir, Alaska.

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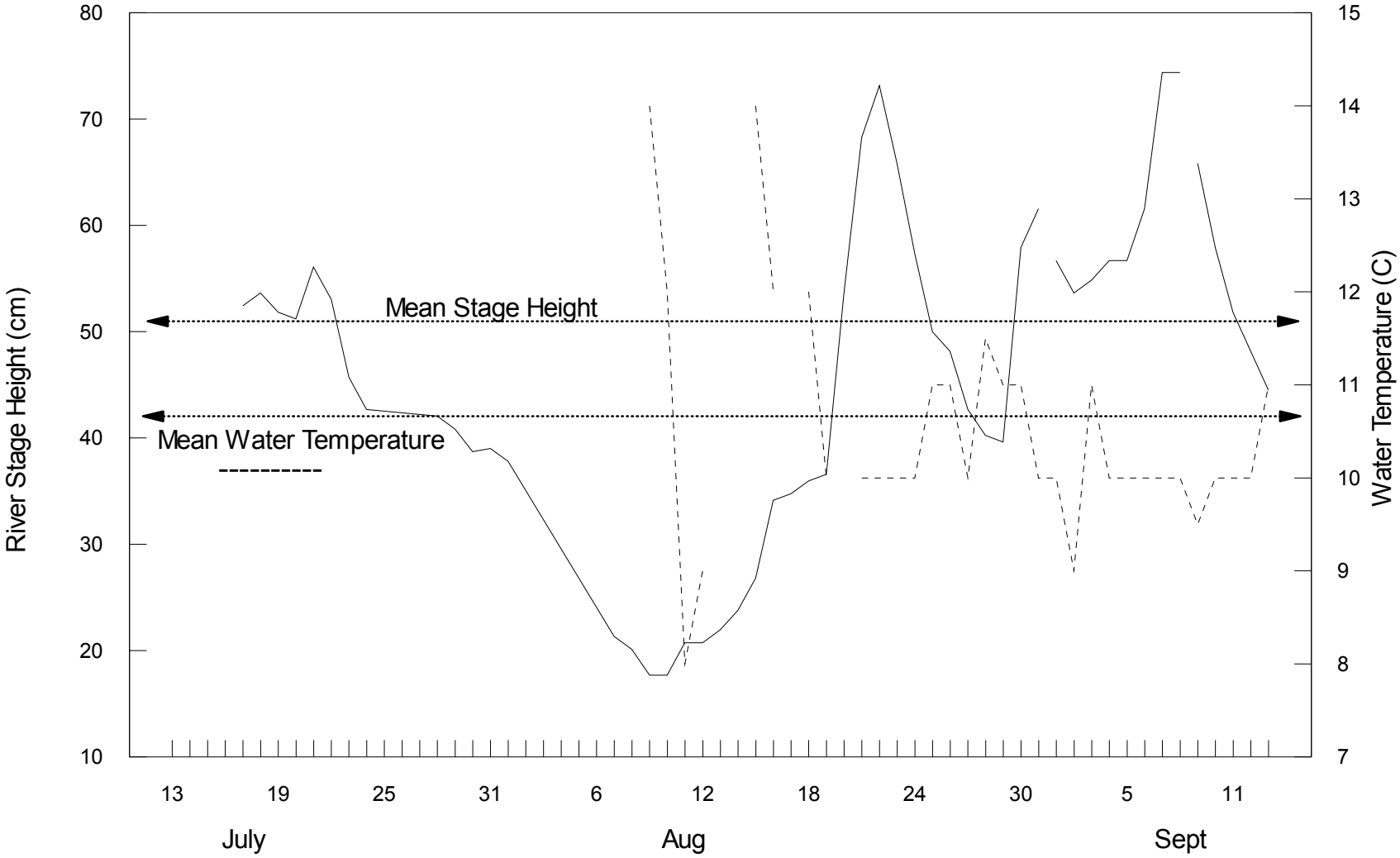


Appendix 1. - River stage heights and water temperatures at the Kwethluk River Weir, Alaska, 2001.

Appendix 2.-Daily escapement and counting effort at the Kwethluk River weir, Alaska, 2001

Date	Counting Effort (hrs)	Chum Salmon	Chinook Salmon	Sockeye Salmon	Pink Salmon	Coho Salmon	Gill Net Marks: Chum Salmon	Gill Net Marks: Chinook Salmon	Gill Net Marks: Sockeye Salmon	Gill Net Marks: Pink Salmon	Gill Net Marks: Coho Salmon	Dolly Varden	Whitefish	Northern Pike	Arctic Grayling
8/12	1.75	28	4	4	3	196	0	0	0	0	0	0	0	0	0
8/13	9.25	86	61	54	15	949	0	2	0	0	17	0	0	0	0
8/14	12.00	59	30	5	15	376	0	0	0	0	1	0	15	0	0
8/15	10.00	56	7	1	9	1,857	0	0	0	0	25	0	41	0	0
8/16	11.00	25	11	0	8	749	0	0	0	0	25	0	53	0	0
8/17	12.50	31	4	0	6	423	0	0	0	0	2	0	50	0	0
8/18	10.25	16	4	1	5	194	0	0	0	0	1	0	38	0	0
Total:	66.75	301	121	65	61	4,744	0	2	0	0	71	0	197	0	0
8/19	13.25	9	4	0	10	1,706	1	0	0	0	14	0	41	0	0
8/20	13.25	3	0	0	1	347	0	0	0	0	2	0	1	0	0
8/21	1.75*	0	0	0	0	11	0	0	0	0	0	0	0	0	0
8/22	10.00*	8	0	0	0	348	0	0	0	0	0	0	18	0	0
8/23	13.75	4	0	0	0	599	0	0	0	0	6	0	10	0	0
8/24	14.00	4	0	1	3	822	0	0	0	0	4	0	3	0	0
8/25	15.00	1	0	0	4	1,026	0	0	0	0	16	0	12	0	0
Total:	69.25	29	4	1	18	4,859	1	0	0	0	42	0	85	0	0
8/26	13.75	1	1	1	4	1,237	0	0	0	0	26	0	23	0	2
8/27	12.50	2	1	0	3	789	0	0	0	0	15	0	11	0	0
8/28	13.50	5	0	0	0	679	0	0	0	0	6	1	23	0	2
8/29	11.00	2	1	0	0	1,892	0	0	0	0	36	0	33	0	0
8/30	11.75	2	0	0	0	1,366	0	0	0	0	38	0	18	0	1
8/31	14.25	1	0	0	1	294	0	0	0	0	3	0	12	0	0
9/9	15.00	2	0	0	1	446	0	0	0	0	14	0	4	0	0
Total:	91.75	15	3	1	9	6,703	0	0	0	0	138	1	24	0	5

Appendix 2.- (Continued)

Date	Counting Effort (hrs)	Chum Salmon	Chinook Salmon	Sockeye Salmon	Pink Salmon	Coho Salmon	Gill Net Marks: Chum Salmon	Gill Net Marks: Chinook Salmon	Gill Net Marks: Sockeye Salmon	Gill Net Marks: Pink Salmon	Gill Net Marks: Coho Salmon	Dolly Varden	Whitefish	Northern Pike	Arctic Grayling
9/2	15.00	1	0	0	0	723	0	0	0	0	16	0	8	0	0
9/3	14.00	3	0	0	2	492	0	0	0	0	13	2	4	0	0
9/4	13.50	1	0	0	1	578	0	0	0	0	12	0	3	0	0
9/5	14.00	0	0	0	1	378	0	0	0	0	9	0	5	0	0
9/6	14.50	0	0	0	0	311	0	0	0	0	9	0	3	0	0
9/7	0.00*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/8	0.00*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total:	71.00	5	0	0	4	2,482	0	0	0	0	59	2	23	0	0
9/9	9.00	0	0	0	2	43	0	0	0	0	0	0	0	0	0
9/10	13.00	0	0	0	2	85	0	0	0	0	0	0	6	0	0
9/11	13.00	1	0	0	2	108	0	0	0	0	2	0	23	0	0
9/12	13.00	0	0	0	1	100	0	0	0	0	0	0	0	0	0
9/13	16.00	2	1	0	3	72	0	0	0	0	0	0	7	0	0
9/14	*														
9/15	*														
Total:	64.00	3	1	0	10	408	0	0	0	0	2	0	36	0	0
Cumulative Totals:	362.75	353	129	67	102	19,196	1	2	0	0	312	3	465	0	5

Appendix 3. -Age, sex, and length of chinook salmon captured with 11.4 cm (bar measure) gill net in the Kwethluk River, Alaska, 2001.

Sampling Dates (Stratum Dates)	Sex		Brood Year and Age Class				Sex
			1998	1997	1996		
			1.2	1.3	1.4	Total	Ratio*
7/29, 7/30, 7/31	Male	Mean Length	561	697	857		87.2
		Std. Error	9	13	17		
		Range	495-640	585-800	691-1020		
		Sample Size	24	20	23	68	
	Female	Mean Length	0	885	887		12.8
		Std. Error	0	0	18		
		Range	0	885-885	770-950		
		Sample Size	0	1	9	10	

* Sex ratio does not reflect population due to selectivity of gill net.

Appendix 4.-Observed and reconstructed daily counts, cumulative counts, and cumulative proportion of coho salmon escapement through the Kwethluk River Weir, Alaska, 2001

	Coho Salmon Escapement					
	2001 Observed			2001 Reconstruction		
		Cumulative			Cumulative	
Date	Count	Count	Proportion	Count	Count	Proportion
07/19				0	0	0.000
07/20				0	0	0.000
07/21				2	2	0.000
07/22				4	6	0.000
07/23				6	12	0.001
07/24				5	17	0.001
07/25				8	24	0.001
07/26				9	34	0.002
07/27				12	45	0.002
07/28				15	61	0.003
07/29				9	70	0.003
07/30				24	93	0.004
07/31				55	148	0.007
08/01				56	204	0.009
08/02				52	256	0.012
08/03				100	356	0.016
08/04				84	440	0.020
08/05				126	567	0.026
08/06				147	713	0.033
08/07				121	834	0.039
08/08				89	923	0.043
08/09				165	1088	0.050
08/10				157	1245	0.058
08/11				430	1675	0.078
08/12	196	196	0.010	196	1871	0.087
08/13	949	1145	0.060	949	2820	0.131
08/14	376	1521	0.079	376	3196	0.148
08/15	1857	3378	0.176	1857	5053	0.234
08/16	749	4127	0.215	749	5802	0.269
08/17	423	4550	0.237	423	6225	0.288
08/18	194	4744	0.247	194	6419	0.297
08/19	1706	6450	0.336	1706	8125	0.376
08/20	347	6797	0.354	347	8472	0.392
08/21	11	6808	0.355	352	8824	0.409
08/22	348	7156	0.373	348	9172	0.425
08/23	599	7755	0.404	599	9771	0.452
08/24	822	8577	0.447	822	10593	0.491
08/25	1026	9603	0.500	1026	11619	0.538
08/26	1237	10840	0.565	1237	12856	0.595
08/27	789	11629	0.606	789	13645	0.632
08/28	679	12308	0.641	679	14324	0.663
08/29	1892	14200	0.740	1892	16216	0.751
08/30	1366	15566	0.811	1366	17582	0.814
08/31	294	15860	0.826	294	17876	0.828

Appendix 4. - (Continued).

	Coho Salmon Escapement					
	2001 Observed			2001 Reconstruction		
		Cumulative			Cumulative	
Date	Count	Count	Proportion	Count	Count	Proportion
09/01	446	16306	0.849	446	18322	0.848
09/02	723	17029	0.887	723	19045	0.882
09/03	492	17521	0.913	492	19537	0.905
09/04	578	18099	0.943	578	20115	0.931
09/05	378	18477	0.963	378	20493	0.949
09/06	311	18788	0.979	311	20804	0.963
09/07	0	18788	0.979	136	20939	0.970
09/08	0	18788	0.979	162	21102	0.977
09/09	43	18831	0.981	128	21230	0.983
09/10	85	18916	0.985	85	21315	0.987
09/11	108	19024	0.991	108	21423	0.992
09/12	100	19124	0.996	100	21523	0.997
09/13	72	19196	1.000	72	21595	1.000

Appendix 5.- Estimated age and sex composition of weekly coho salmon escapements through the Kwethluk River weir, Alaska, 2001; and estimated design effects of the stratified sampling design.

		Brood Year and Age Class			
		1999	1998	1997	
		1.1	2.1	3.1	Total
Stratum 1: 8/12 - 8/18					
Sampling Dates: 8/15, 8/16, 8/17					
Male:	Number in Sample:	5.0	36.0	3.0	44.0
	Estimated % of Escapement:	5.4	38.7	3.2	47.3
	Estimated Escapement:	255.1	1836.4	153.0	2244.5
	Standard Error:	110.5	238.5	86.5	
Female:	Number in Sample:	5.0	44.0	0.0	49.0
	Estimated % of Escapement:	5.4	47.3	0.0	52.7
	Estimated Escapement:	255.1	2244.5	0.0	2499.5
	Standard Error:	110.5	244.5	0.0	
Total:	Number in Sample:	10.0	80.0	3.0	93.0
	Estimated % of Escapement:	10.8	86.0	3.2	100.0
	Estimated Escapement:	510.1	4080.9	153.0	4744.0
	Standard Error:	151.7	169.8	86.5	
Stratum 3: 8/26 - 9/01					
Sampling Dates: 8/27, 8/28, 8/29					
Male:	Number in Sample:	8.0	35.0	1.0	44.0
	Estimated % of Escapement:	9.1	39.8	1.1	50.0
	Estimated Escapement:	609.4	2666.0	76.2	3351.5
	Standard Error:	205.2	349.4	75.7	
Female:	Number in Sample:	4.0	40.0	0.0	44.0
	Estimated % of Escapement:	4.5	45.5	0.0	50.0
	Estimated Escapement:	304.7	3046.8	0.0	3351.5
	Standard Error:	148.7	355.5	0.0	
Total:	Number in Sample:	12.0	75.0	1.0	88.0
	Estimated % of Escapement:	13.6	85.2	1.1	100.0
	Estimated Escapement:	914.0	5712.8	76.2	6703.0
	Standard Error:	245.0	253.3	75.7	

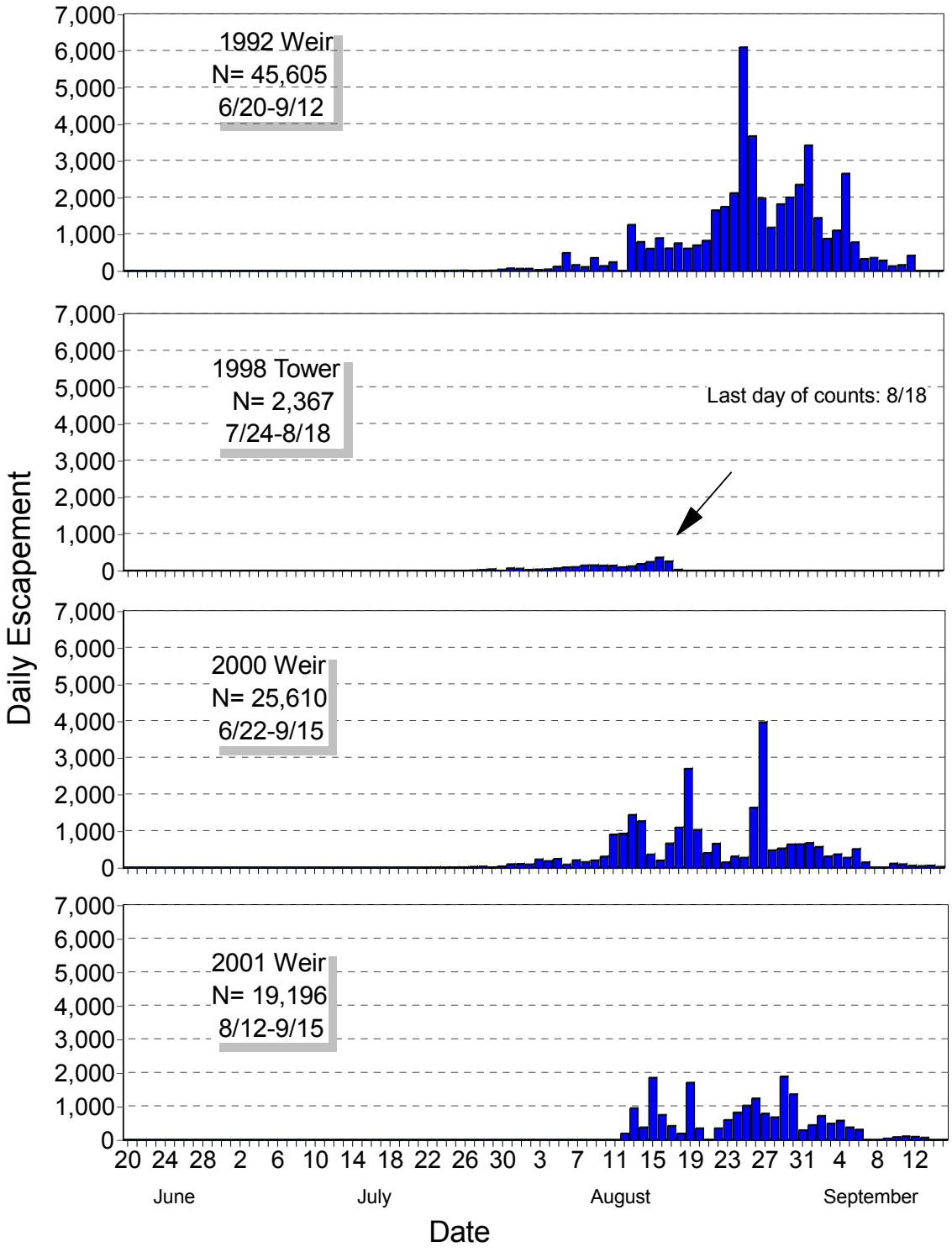
Appendix 5.- (Continued).

		Brood Year and Age Class			
		1999	1998	1997	
		1.1	2.1	3.1	Total
Strata 1-3:	8/12 - 9/1				
Male:	Number in Sample:	13.0	71.0	4.0	88.0
	% Males in Age Group:	14.8	80.7	4.5	100.0
	Estimated % of Escapement:	7.5	39.3	2.0	48.8
	Estimated Escapement:	864.4	4502.4	229.2	5596.0
	Standard Error:	233.1	423.1	114.9	
	Estimated Design Effects:	0.7	0.6	0.7	0.6
Female:	Number in Sample:	9.0	84.0	0.0	93.0
	% Females in Age Group:	9.6	90.4	0.0	100.0
	Estimated % of Escapement:	4.9	46.2	0.0	51.1
	Estimated Escapement:	559.7	5291.3	0.0	5851.0
	Standard Error:	185.2	431.4	0.0	
	Estimated Design Effects:	0.7	0.6	0.0	0.6
Total:	Number in Sample:	22.0	155.0	4.0	181.0
	Estimated % of Escapement:	12.1	85.6	2.0	100
	Estimated Escapement:	1424.2	9793.6	229.2	11447.0*
	Standard Error:	288.2	305.0	114.9	
	Estimated Design Effects:	0.7	0.3	0.7	

* Estimated escapement for strata in which samples were taken

Appendix 6.- Length (mm) at age for coho salmon, Kwethluk River weir, Alaska, 2001.

Sampling Dates (Stratum Dates)	Sex		Brood Year and Age Class 1999 1.1	1998 2.1	1997 3.1
8/15, 8/16, 8/17 (8/12 - 8/18)	Male	Mean Length	597	603	575
		Std. Error	15	6	8
		Range	540-625	530-670	565-590
		Sample Size	5	36	3
	Female	Mean Length	593	589	
		Std. Error	14	5	
		Range	540-615	490-640	
		Sample Size	5	44	0
8/27, 8/28, 8/29 (8/23 - 9/15)	Male	Mean Length	594	608	615
		Std. Error	9	5	
		Range	555-620	555-655	615-615
		Sample Size	8	35	1
	Female	Mean Length	556	595	
		Std. Error	19	5	
		Range	515-600	495-635	
		Sample Size	4	40	0
Seasonal	Male	Mean Length	595	606	588
		Std. Error	8	4	8
		Range	540-625	530-670	565-615
		Sample Size	13	71	4
	Female	Mean Length	573	592	
		Std. Error	12	3	
		Range	515-615	490-640	
		Sample Size	9	84	0



Appendix 7.- Daily coho salmon escapement through the Kwethluk River weir (1992, 2000-01) and counting tower (1997), Alaska.